Species and distribution of mountain bamboos in Shennongjia, Central China

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Abstract: Inventory recorded 4 genera and 11 species of mountain bamboos in Shennongjia, Central China. Of these, 4 species (*Phyllostachys nigra* var. *henonis*, *Ph. heteroclada*, *Ph. nidularia* and *Ph. bambusoides*) belong to the monopodial bamboo, 4 species (*Indocalamus latifolius*, *I. longiauritus*, *I. wilsoni* and *I. tessellatus*) to the amphipodial bamboo, and 3 species (*Fargesia spathacea*, *F. murielae* and *Yushania confusa*) to the sympodial bamboo. Monopodial bamboos grow on the gentle slopes below 1 800 m asl, occurring from the subtropical belt to the temperate belt in the vertical climatic spectrum of the mountain; Sympodial bamboos occur in higher elevations, ranging from the warm temperate (1 200 m), across the mediate temperate and cold temperate, to the mountaintops of the frigid temperate belt (3 100 m). Amphipodial bamboos occur in all climate types except the frigid temperate belt. Three dominant species, *F. spathacea*, *F. murielae* and *Y. confusa*, currently cover 12 %, 9 % and 3 % of the mountain ranges in Shennongjia, respectively.

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Introduction

On 17 April 1907, Ernest Wilson (1876-1930) collected "one of the most beautiful Chinese bamboos" from Shennongjia in northwest Hubei of Central China (Sargent 1913). This bamboo was named *Arundinaria murielae* after Wilson's daughter, Muriel, by Gamble in 1920 (Keng 1987). Later it was assigned to a newly established genus *Sinarundinaria* Nakai in 1935 (Li 1996). Presently it is in the genus of *Fargesia* Franchet (e.g. Yi 1988; Stapleton 1995; Keng and Wang 1996). *Murielae* (umbrella bamboo as the common name) was introduced to Kew Gardens in the early 20th century and all plants in European countries are the vegetative offspring of this clone (Eberts 1996; Gielis 1999). Umbrella bamboo is the most successful and widely grown ornamental bamboo in the West, however, it is odd that no species in Shennongjia has been exactly described as *murielae* in the local botanical accounts (e.g., Zheng *et al.* 1980; Ban *et al.* 1995; Zhu and Song 1999).

Beside *murielae*, two other bamboo species collected by Augustine Henry (1857-1930) in Shennongjia in 1888 were involved in taxonomic controversies over the genera of *Fargesia* Franchet, *Thamnocalamus* Munro, and *Sinarundinaria* Nakai (Keng 1987; Yi 1988; Stapleton 1995, 1997; Li 1996). Specimen *Henry 6938* was cited as the type specimen of *Thamnocalamus spathaceus* (Franch.) Soderstron (Soderstrom 1979), however, Yi (1997) argued that it should be *Fargesia spathacea* Franchet. Specimen *Henry 6832* represents a complex confusion in the bamboo classification. When Otto Stapf described the fountain bamboo *Arundinia nitida*, he was actually describing material from two collections (Keng 1987; Stapleton 1995; Li 1996): one was from the living plants raised from bamboo seeds collected by Berezowski in south Gansu Province of China in 1886; the other was the fertile specimen *Henry 6832* collected by A. Henry in Shennongjia in 1888 (Keng 1987). Later, the vegetative collection was cited by Nakai (1935) as the type, together with *murielae*, for establishing the new genus of *Sinarundinaria*. *Henry 6832* was separated from *nitida* by McClure as a different species *Indocalamus confusus* (McClure 1940; Keng 1997), now renamed as *Yushania confusa* (McClure) Z.P. Wang & G.H. Ye (Keng and Wang 1996). Facing this confusion, Stapleton (1997) called for more information on mountain bamboos from western Hubei.

The study of mountain bamboos in Shennongjia was beset with several problems. Firstly, the importance of mountain bamboos in Shennongjia was overlooked, partly because giant pandas became extinct in this region at the late 19th century (Loucks *et al.* 2001) and the mistakes in bamboo classification have not been really noticed. Secondly, geographic remoteness and inaccessibility isolated the high mountains of Shennongjia in which bamboos dominate the forest floors. Thirdly, general plant inventory is difficulty to present a good picture of the bamboo diversity, as there might have been difficulties and errors in the identification of bamboo species. Correspondingly, this investigation aims to make a comprehensive understand-

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ing of the diversity and distribution of mountain bamboos in Shennongjia.

Methods

Bamboo specimens were collected between June 2000 and August 2001 over the mountain ranges in Shennongjia. The collection was restricted to the wild and semi-wild species inside the Shennongjia National Nature Reserve. Visits outside the reserve were made to collect additional bamboos; and popular cultivated bamboos were sampled wherever encountered. The bamboos growing in the house-gardens were not included. A total of 110 sheets of bamboo specimens were collected. Initial identifications were made using taxonomic keys and manuals, which include: Flora Republicae Popularis Sinicae, Tomus 9(1) (Keng and Wang 1996), Compendium of Chinese Bamboo Species (Zhu *et al.* 1994), Compendium of Bamboos in Sichuan (Yi 1997), and The Plants of Shennongjia (Zheng *et al.* 1980). Nomenclature of taxa principally followed Keng and Wang (1996). Identification verification of the taxa was carried out by comparing the collected specimens with the voucher collections in Wuhan University Herbarium, Central China Normal University Herbarium, and the specimens in the Shennongjia National Nature Reserve.

Distribution of each species was expressed in two terms: the altitudinal range and the land coverage. Land coverage estimations were made for three dominant species *F. murielae, F. spathacea* and *Y. confusa*. Relative coverage was estimated on the aero-photos that are stored in the Shennongjia reserve. Species interpreting was based on the field records. The environmental range for each species in terms of annual mean temperature, minimum temperature and annual precipitation was estimated by adapting the elevation range of the species against the linear gradients of altitudinal environments (Zhu and Song 1999). Flowering interval of the bamboo was estimated by integrating the anecdotal evidence and field observation. Observation on flowering year of the sympodial bamboos was carried out by counting the number of rhizomes along a growing sequence, because a rhizome produces only one or two new rhizomes from lateral buds, which form a distinguishable yearly-pattern.

Results

Based on the specimens collected in Shennongjia, a total of 11 bamboo species in four genera were identified (Table 1). Umbrella bamboo (*Fargesia murielae* (Gamble) Yi) still survives in Shennongjia, where it dominates the forest floor between 2 400 and 3 100 m a.s.l. This species was wrongly named as the fountain bamboo (*Sinarundinaria nitida* (Mitf.) Nakai) in the local accounts (e.g., Zheng *et al* 1980; Ban 1995; Zhu and Song 1999). There are obvious differences between these two species. i.e., the culm sheath of *murielae* is relatively shorter than the internodes and with a round top, while the culm sheath of *nitida* is longer than the internodes and with a triangular top.

Typical taxonomical changes can be observed with regard to *F. murielae*. Wilson collected this species from Shennongjia in 1907 (*Wilson 1462*). Rendle (in Sargent 1913) did not describe this new species, but titled it as an uncertain taxon "*Arundinaria* sp". Consequently, the early Chinese botanists could not describe this species according to the most authoritative reference on the flora in Central China, "Plantae Wilsonianae" (Sargent 1913-1916). Until the late 1970s, *murielae* did not appear in authoritative taxonomic books in China, e.g., "Iconographia Comorphytorum Sinicorum" (Beijing Botanical Insitute 1976). In 1980, "Plants in Shennongjia" first treated this species as *Sinarundinaria nitida* (mitf.) Nakai, following the "Iconographia" (Zheng *et al.* 1980). In fact, *Fargesia* (*Sinarundinaria*) *nitida* growing in western Sichuan and southern Gansu simultaneously flowered in 1980s (Keng and Wang 1996; Yi 1997), while *F. murielae* endemic to Shennongjia flowered in 1990s. Since most bamboo taxonomists agreed to join *Sinarundinaria* with the genus *Fargesia* (Yi 1988; Keng 1987; Stapleton 1997), *murielae* received the full name *Fargesia murielae* (Gamble) Yi.

Arrow bamboo (*Fargesia spathacea* Franch.) is another dominant mountain bamboo in Shennongjia between 1 200 and 2 600 m a.s.l. This species was first recorded as *Sinarundinaria sparsiflora* (Rendle) Keng f. in the local account (Zheng *et al* 1980). The species flowered simultaneously in the mid 1980s (1984-1988). Soderstrom (1979) cited Specimen *Henry 6938* as the type of *Thamnocalamus spathaceus* (Franch.); however, Yi (1997) argued that it should be *F. spathacea* (Franchet) Yi (1996) since its flower is certainly a *Fargesia* type (Yi 1997). Thus, *Thamnocalamus spathaceus* was treated as a synonym of *Fargesia spathacea* Franch..

Phyllostachys is perhaps the most abundant and important genus in China (Zhu *et al.* 1994). The genus consists of 48 species, among which *Phyllostachys heterocycla var. pubescens* (or *Ph. pubescens*) is the most abundant, covering 2.8 million ha, almost two thirds of the total bamboo area in the country (Keng and Wang 1996). Local accounts in Shennongjia recorded seven *Phyllostachys* species, however most of them are cultivated species outside the reserve. Four species, *Ph. nigra* var. *henonis* (Bean) Stapf. ex Rendle, *Ph. heteroclada* Oliver, *Ph. nidularia* Munro and *Ph. bambusoides* Siebold & Zucc, were recorded. Water bamboo, *Ph. heterooclada*, is a native species mainly distributed along the riverbanks between 800 and 1500 m asl, while henon bamboo *Ph. nigra* var. *henonis* is a naturalized semi-wild species. It was observed that in a cultivated plot (N 31º 27.965', E 110º 23.680', alt. 1 250 m a.s.l; Area: 0.2 hm^2), the henon bamboo flowered in 1993 and all culms then apparently died, but there were no seeds from the parent plants and thus no sexual regeneration through seedlings took place. The rhizomes began to produce shoots in the following years. Inside an old stand, all new

shoots flowered again and the rhizomes finally decayed, while on the margins of the old stand, only a few individual bamboo culms flowered and the bamboo stands were restored in about 6-7 years.

Unlike *Fargesia* bamboos, *Yushania confusa* (McClure) Z.P. Wang et G.H. Ye has not been recorded on the local account. It is difficult to clearly distinguish *Yushania* bamboos from *Fargesia* bamboos in their vegetative form. However, the rhizomes of these two genera are totally different. A typical rhizome of *Fargesia* bamboo is usually thicker than the culm, solid without air channels, and both ends are thicker than its middle part, while a rhizome of *Yushania* bamboo is slender and longer, usually with a caliber and many air canals, and both ends are much thicker than the middle part. Augustine Henry collected the flowering specimen of *confusa* (*Henry 6832*) in 1888, after then it did not flower until 1976-1979. Since *Yushania* bamboos have a simultaneous flowering behavior (Keng and Wang 1996), it can be estimated that the flowering interval of *Y. confusa* is about 88 years.

Table 1. Species and environmental ranges of mountain bamboos in Shennongjia, Central China

Species	Elevation /m	Rhizome type	Clump type	Ann.Temp./ ºC	Min. Temp. /ºC	Ann.Precip. /mm
Indocalamus latifolius	500-1200	Amphimorph	Semi-running	10-14	-1	650-1230
Indocalamus wilsoni	1700-2400	Amphimorph	Running	4-7	-7	1630-2200
Indocalamus longiauritus	500-1300	Amphimorph	Semi-running	9-14	-2	650-1300
Indocalamus tessellatus	500-1000	Amphimorph	Semi-running	11-14	0	650-1050
Phyllostachys nigra henonis	500-1800	Monomorph	Running	7-14	-4	650-1710
Phyllostachys heteroclada	500-1400	Monomorph	Running	9-14	-2	650-1380
Phyllostachys bambusoides	500-1300	Monomorph	Running	9-14	-2	650-1300
Phyllostachys nidularia	500-1200	Monomorph	Clumping	9-14	-1	650-1230
Fargesia spathacea	1200-2600	Symmorph	Clumping	3-10	-8	1220-2360
Fargesia murielae	2400-3100	Symmorph	Clumping	1-4	-10	2200-2770
Yushania confusa	1200-2300	Symmorph	Semi-running	4-10	-6	1230-2120

In the table Ann. Temp. = Mean annual temperature, Min. Temp. = Minimum of monthly mean temperature over the year (in January), Ann. Precip. = Annual precipitation.

Table 2. Flowering and land cover of mountain bamboos in Shennongjia, Central China

Species	Culm height /m	Land cover (%)	Flowering type	Last flowering	Flowering interval (year)
Indocalamus langiauritus	1.8-2.2	< 1 %	Unknown	Unknown	Unknown
Indocalamus wilsoni	0.6-1.1	1-2 %	Sporadic	1997-98	Unknown
Indocalamus latifolius	1.5-2.0	1-2 %	Unknown	Unknown	Unknown
Indocalamus tessellatus	1.0-2.0	< 1 %	Unknown	Unknown	Unknown
Phyllostachys nigra henonis	4.0-8.0	1-2 %	Gregarious	1993	40-50
Phyllostachys bambusoides	4.0-10.0	< 1 %	Unknown	Unknown	unknown
Phyllostachys nidularia	4.0-6.0	< 1 %	Sporadic	Frequently	Unknown
Phyllostachys heteroclada	2.0-6.0	< 1 %	Gregarious	1958	50-60
Fargesia spathacea	2.0-5.0	12 %	Gregarious	1984-88	110
Fargesia murielae	2.0-4.5	8 %	Gregarious	1996-2000	35
Yushania confusa	1.5-3.0	3 %	Gregarious	1976-79	88

Over the mountain ranges, another group of wild bamboos is to be found: *Indocalamus* bamboos. Most members of the *Indocalamus* group are native to China (Keng and Wang 1996). Inside Shennongjia, four species were discovered: *Indocalamus latifolius* (Keng) McClure, *I. tessellatus* (Munro) Keng f., *I. longiauritus* Hand.-Mazz. and *I. wilsoni* (Rendle) C.S. Chao et C.D. Chu (*I. nubigenus* in local account). *Indocalamus* bamboos mainly grow in low mountains between 500 and 1300 m asl, however *I. wilsoni* occurs in the upper mountains between 1700 and 2400 m asl.

Discussion

Of 11 bamboo species in Shennongjia, each species has a specific altitudinal range with preferred temperature and precipitation (Table 1). Monopodial *Phyllostachys* bamboos spread by fast-growing underground rhizomes and are thus known as running bamboos (Yi 1997). Their rhizome system is extremely tough, enabling a well-established grove to be drought-resistant and tolerant of cold winters. They are widely planted for edible shoots and for poles, or for stabilizing soils and controlling erosion. In Shennongjia, *Ph. nidularia* and *Ph. heteroclada* are wild species, while

Ph. nigra var. *henonis* and *Ph. bambusoides* are naturalized species. Here monopodial bamboos can only grow on the gentle slopes below 1800 m, occurring in from subtropical belt to temperate belt along the vertical climatic spectrum along the mountains.

Sympodial bamboos usually form a cluster of culms and are known for their non-invasive behavior (Yi 1997). They are slow-growing, with a graceful arching habit. *F. spathacea* and *Y. confusa* occur in areas ranging from the warm temperate (ca. 1 200 m), across the temperate, to the cold temperate belts. *F. murielae* occurs from 2 500 m toward the summit of 3 100 m, in a frigid-temperate belt.

Amphipodial bamboos occur in all climate types except the frigid-temperate belt in Shennongjia. *Indocalamus longiauritus*, *I. latifolius*, and *I. tessellates* commonly grow in the low mountains, while *I. wilsoni* grows under forests in the upper mountains between 1 700 to 2 400 m. *Indocalamus* bamboos in the lower mountains usually bear giant leaves which are in great demand in the growing Chinese market.

The natural world is extremely dynamic, due to both intrinsic ecological factors and increasing human influences. In such complex natural systems, setting priorities is a necessary prerequisite for effective biodiversity conservation. The judgment of conservational priority in plants usually depends on the understanding on the species distribution. According to their distribution ranges (Zhu *et al.* 1994), all bamboos occurring in Shennongjia are native Chinese species. Of these, *F. murielae* is endemic solely to Shennongjia, and *F. spathacea, Y. confusa, I. wilsoni* are endemic to Central China with Shennongjia as their distribution center. These four species should be put into the conservation accounts in Shennongjia.

Some Shennongjia bamboos have already appeared in the Western gardens, e.g., *F. murielae, F. spathacea, Ph. nigra* var. *henonis, Ph. heteroclada,* and *Ph. bambusoides* (Shor 2002). However, some species not yet introduced also have a high potential. For example, *I. wilsoni* is a dwarf bamboo with spreading rhizomes that are able to cover the ground very quickly, which may be suitable for recovering degraded land in temperate regions. *I. langiauritus, I. latifolius*, and *I. tessellatus* can be cultivated as new bamboo crops for producing giant leaves for both food and chemical industries.

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